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ON THE GENESIS OF LOWER OLIGOCENE MANGANESE DEPOSITS IN GEORGIA

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On the territory of Western Georgia numerous deposits and shows of manganese, silicite and phosphorite are known at the base of the Lower Oligocene *(Fig. 1)*. These minerals occur in a close association and there is no doubt about their genetic relations.

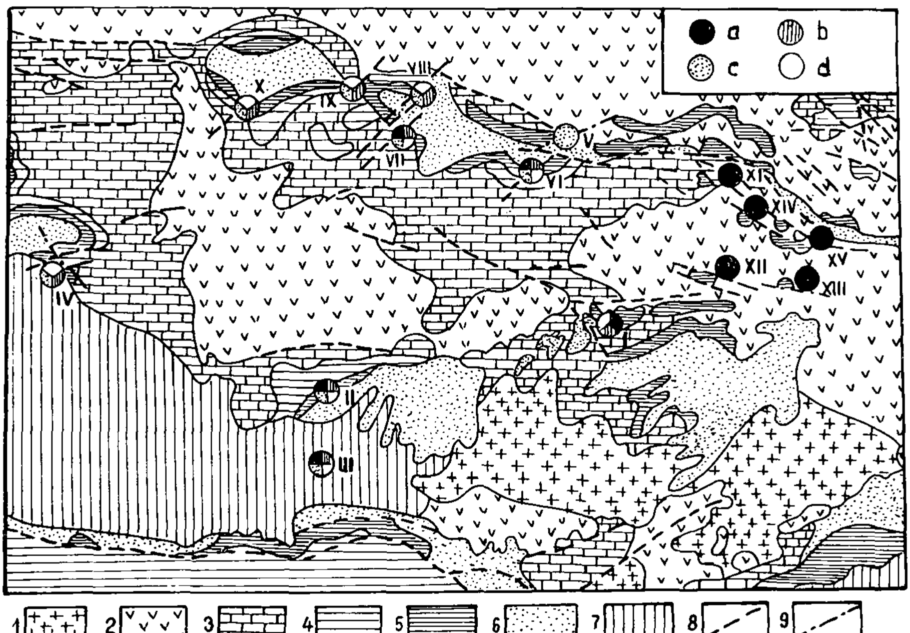

Fig. 1. Distribution scheme of Lower Oligocene deposits and ore shows of Mn, Si, Fe and P in Western Georgia.

1 — crystalline rocks of Dzirulsk massif; *2* — the Jurassic; *3* — the Cretaceous; *4* — the Paleocene — Eocene; *5* — the Oligocene — Lower Miocene (Maikop Series); *6* — the Neogene; *7* — Quaternary deposits; *8* — disjunctive dislocations; *9* — disjunctive dislocations controlling mineralization. Deposits and ore shows: I — Chiatura deposit, II—III — Kviril depression, IV — Megreli depression, V—X — Racha-Lechkhum depression, XI—XV — Shkmeri-Meleshursk group. *a* — manganese, *b* — phosphorites, *c* — glauconites and glauconitic sandstones, *d* — silicites.

All the deposits and shows of these minerals are associated with a horizon of siliceous-zeolitic tuffs and tuffites *(Fig. 2)*, in which zeolite is represented by clinoptilolite and silica — by opal, frequently recrystallized into chalcedony [MAKHARADZE, 1972].

Manganese, iron and phosporus are localized in the bottom part of the horizon and form an ore subhorizon, the structure of which varies in different exposures *(Fig. 1)*. The Chiatura deposit is monomineralic — manganese; shows in Racha-Lechkhum depression — bimetallic: iron and manganese; of a bimetallic nature is also a deposit in the axial zone of Kviril depression, changing into a monometallic (manganese) on the northern flank in the coastal stretch. In Megreli and in some parts of Racha-Lechkhum depression the ore subhorizon is represented by iron mineralization exclusively or is absent. Manganese is represented by oxides, hydroxides and carbonates, whereas iron — by glauconite, more rarely by hematite and hydrohematite. Phosphorites represented by francolite and collophane act in the ore subhorizon as cement for glauconites and glauconitic tuffs or tuffites forming also separate nodules with abundant inclusion of glauconite. In Chiatura deposit, contrary to other regions, phosphorites not containing glauconite form an independent parting of a nodular structure with a maximum thickness of 15 cm; it underlies the ore subhorizon along the so-called Main Fault that limits the deposit from the south-west. Here a barite mineralization is also recorded acting as a cement of phosphorites.

Silicites occur mostly in the middle part of the horizon of siliceous-zeolitic tuffs and tuffites, while their separate bands can also be found in the ore subhorizon. Silicites are represented by spongolites and opalolites, in which the content of pyroclastic and terrigenous material, opal, clinoptilolite and montmorillonite formed through the replacement of vitric ash varies within a wide range. The carbonate substance of silicites is mostly represented by dolomite and is present in a comparatively small amount; in Chiatura deposit it is completely absent.

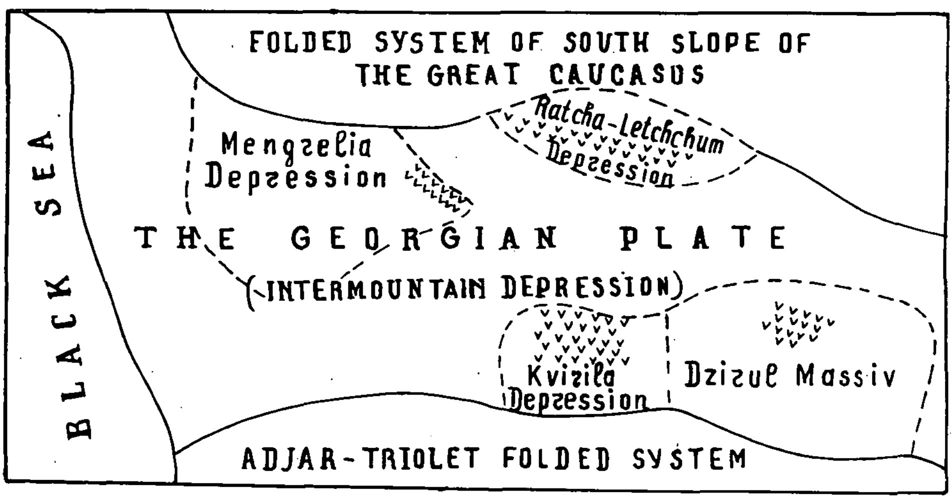

Fig. 2. Distribution scheme of the horizon of siliceous-zeolitic tuffs and tuffites of Lower Oligocene age on the territory of Western Georgia.

Fullest information and abundant material on the genesis of the minerals mentioned is accumulated for the Chiatura manganese deposit. The sedimentary origin of Chiatura deposit leaves no doubts, but there is no single opinion on its source. The available factual material indicates that Mn and the accompanying Si, Fe and P are not terrigenous, but are supplied by hydrothermal solutions and exhalations, as has been shown by G. S. DZOTSENIDZE [1969].

In Lower Oligocene manganese deposits and shows the accumulation of not only Mn, but also of Si, Fe and P is not being controlled by the mineral and granulometric composition of the terrigenous material, its influence being reflected only in its diluting effect. Both in the ore subhorizon and in the horizon of siliceous-zeolitic tuffs and tuffites, the terrigenous material varies by its mineral composition in different regions. In Dzirulsk massif, for instance, the terrigenous complex is characterized by a quartz-arkose composition, in Kviril depression it has an admixture of graywacke material. In Megreli and Racha-Lechkhum depressions the terrigenous complex is arkose-graywacke-quartzose. The accumulation of silica, manganese, iron, phosphorus and the formation of zeolite becomes superimposed on different rocks: sandstones, siltstones, clays, marls and limestones.

The above-mentioned lack of uniformity in the nature of structure of individual deposits and shows as well as the Mn, Si, Fe, P and Ba association are typical for a volcano-sedimantary type of deposits and alien to terrigenous-sedimentary types. The complicated pattern of interrelations between Mn, Si, Fe, P and Ba in separate Lower Oligocene deposits and shows can not be explained by the sequence of their evacuation from the crust of weathering according to the scheme of N. A. LISITZYNA [1968] or by the laws of normal sedimentary processes formulated by N. M. STRAKHOV [1963]. Elements belonging to different groups of the mobility series are found in a close association and against a uniform facies background produce maximum accumulations. The evacuation sequence of individual components in a sediment does not coincide with the sequence of their removal from the crust of weathering. At Chiatura deposit, for instance, the manganese ore process is preceeded by an accumulation of phosphates with barite. In deposits and shows of a bimetallic type iron though having lower mobility than manganese, is in a close association with the latter. In the shows of Racha-Lechkhum depression ferruginous bands alternate with manganese-bearing, while carbonate manganese ores contain inclusions of glauconite. In Kviril depression iron has maximum accumulations not in the coastal, but in the deeper part of the basin, where it forms both independent bands of glauconite, hematite and hydrohematite underlying and intercalating with manganese, and iron-manganese oolites.

One of the main proofs of a volcanic accumulation of Mn, Si, Fe and P serves their association with the horizon of siliceous-zeolitic tuffs and tuffites.

Very important is the question on the location of the sources of the ore substance and on the ways by means of which it is supplied to the basin.

There is a distincly expressed regularity in the spatial distribution of Lower Oligocene deposits and shows of Mn, Si, Fe and P that sheds light on the location of sources of the ore substances and on the ways of their supply to the basin. All the Lower Oligocene deposits and shows of Mn, Si, Fe and P are associated with disjunctive dislocations exclusively (*Fig. 1*). The farther from these dislocations the more such deposits peter out, all the fundamental structure features of the ore subhorizon being controlled by the disjunctive dislocations. So, for instance, the Main Fault passes in the extreme south-western part of Chiatura deposit and along this fault: *1)* the manganese ore subhorizon is characterized by its mass and an absence or least quantity of non-ore bands; *2)* silicites are most abundant, becoming more and more replaced by clays with an increase in the distance from the fault; *3)* the thickness of hydrothermally-altered ore is greatest, decreasing and petering out in getting farther away from the fault; *4)* the content of nickel, copper and cobalt in the ore is at its maximum; *5)* phosphorites and barite form maximum accumulations, barite being strontium-bearing.

The Main Fault represents a fracture of a deep-seated type that originated during a pre-Oligocene time, at the end of the Lower or in the beginning of the Middle Miocene it has been subjected to a rejuvenation. Along the plane of the Main Fault there are alterations in carbonate rocks expressed in a dolomitization of limestones, in their replacement by iron, manganese and a leaching resulting in the formation of cavernous textures.

Alterations along the disjunctive dislocations are also observed in the deposits underlying the horizons of siliceous-zeolitic tuffs and tuffites in Megreli and the north-western part of Kviril depressions. Paleocene-Eocene limestones and marle are dolomitized here and silicified; the width of the alteration zone comes to ths first several tens of meters.

In Kviril depression the main source of the ore substance has been located in its west-south-western part, which is indicated in this part of the depression by: *1)* maximum thicknesses of the ore subhorizon and of the silicites; *2)* maximum accumulations of iron in the form of glauconite, hematite and hydrohematite in amounts not below and sometimes exceeding the amounts of manganese *3)* maximum accumulations of phosphorus; *4)* the most rudaceous composition of the pyroclastic material.

Consequently, disjunctive dislocations served as incurrent channels for hydrothermal solutions; apparently, these dislocations were mostly distant from the centres of explosive volcanism, inasmuch as there are no traces of eruption centres anywhere near the places of a maximum accumulation of the ore matter.

The ore matter brought into the basin by the hydrothermae, as indicated by E. A. SOKOLOVA [1968], precipitates as an ordinary mechanical suspension, the place of its precipitation being, to a great extent, determined by physico-geographical conditions and the laws of an ordinary terrigenous sedimentation.

In the Oligocene basin on the territory of Georgia islands that formed the archipelago had dissected coastlines and bays with an uneven floor relief characteristic for a littoral shallow sea. These bays represented traps for the finely dispersed ore matter. The ore suspension was drifted by the currents all over the bay and got buried in places of a weaker hydrodynamic regime — in the hollows of the floor. The morphology of the latter determined the lenticular-bedded texture of the ore subhorizon. At a distance from the source the ore suspension gradually became dispersed in the water.

A most favourable combination of the location of the ore matter source with the paleogeographical environments is recorded for the Chiatura deposit. A maximum accumulation of ore components in the south-western part of the deposit resulted from a direct proximity of the ore matter source and from the paleogeographic environments. In this part of the deposit, despite the neareness of the coastline the supply of terrigenous material and its diluting effect on the ore matter has been small during the time when hydrothermal solutions penetrated into the basin. Such a situation has been determined by the following factors: owing to an intensification of the Oligocene transgression in a south-western direction, the level of erosion was gradually rising and the supply of material from the land constantly diminished; this material has been in a finely dispersed state; limestones, which formed the bulk of the denuded land in the south-western part of the basin, contained small amounts of an unsoluble residue; the narrow isthmus that separated the basin from the Kviril depression did not contribute to the development of abundant rivers that could supply large amounts of terrigenous material.

Among the favourable factors that contributed to the formation of Chiatura deposit mention should be made of the physical properties of rocks through which the metalliferous solutions migrated. The Main Fault dissects crystalline rocks of Dzirulsk massif and the overlying limestones. These rocks are very dense so that the circulating metalliferous solutions are hardly absorbed [DZOTSENIDZE, 1969]. It might be that the comparatively small sizes of ore shows in the Racha-Lechkhum depression and adjacent areas are, to a certain extent, determined by the fact that Middle Bajocian volcanic rocks participating in their structure absorbed a substantial part of the metalliferous solutions letting through to the surface only their small portions.

The first portions of hydrothermal solutions supplied to the Chiatura basin contained Ba, P and Sr. Barium rapidly entered into a reaction with the sulphate-ions of the sea water entrapping part of the strontium and precipitated near the point of issue of the solutions. An intense precipitation of phosphorus was also taking place along the Main Fault, where this element had high concentrations. At a distance from the source phosphorus became rapidly diluted by sea water. The subsequent portions of hydrothermal solutions contained a great amount of manganese. The location of the source of the ore matter in the south-western coastal zone with a well aerated floor determined the oxidation of the Mn^{2+} supplied by the hydrothermal solutions into Mn^{4+} and the formation of pyrolusite-psilomelane ores near the source. Owing to the scarcity of bios in the coastal stretch and a low generation of organic matter by the intensely precipitating manganese hydroxides, the reduction of Mn^{4+} into Mn^{2+} during a diagenesis had been of no substantial importance. The farther from the source in a north-eastern direction, in the abyssal part of the bay, where oxygen is less active, the intensity of the oxidation process and the alteration of Mn^{2+} into Mn^{4+} weakens, and the accumulating amounts of organic matter contribute to a reduction of the oxidized forms of manganese. The pyrolusite-psylomelane ores occurring in the south-western part of Chiatura basin, are gradually replaced in the north-east through manganite ores by carbonate varieties. The overlapping of oxide ores by carbonate ores in the vertical section can be explained by a widening and deepening of the basin and a shifting of the coast line to the south-west.

In Kviril depression, contrary to the Chiatura deposit, hydrothermal solutions contained a substantial amount of iron, which determined the bimetallic nature of the deposit its source having been located in the deep central part of the basin. Near the source iron precipitated as glauconite, more rarely as hematite and hydrohematite and manganese — as manganite and carbonates; there has also been a precipitation here of phosphorites. Manganese could also migrate and get deposited in more distant parts of the basin than the iron, like the coastal stretch of the northern flank of Kviril depression forming pyrolusite-psilomelane ores.

In the Racha-Lechkhum depression the ore matter has been deposited on a basin floor with a highly reduction medium, which determined an exclusive formation of carbonate manganese ores.

In this way, the source of Mn, as well as of the accompanying Si, Fe and P in Lower Oligocene deposits and ore shows consisted in hydrothermal solutions, for which disjunctive dislocations served as incurrent canals. Some deposits and shows had independent sources of supply that differed by the composition of individual components, which determined a varied nature of their structure. The structure, mineral composition and size of Lower Oligocene deposits and shows o manganese, silicite, phosphorites and iron depends not only upon the composition and amount of ore matter supplied by the hydrothermal solutions; an important role belongs also to paleogeographic conditions, the morphology of the basin floor, the hydrodynamic and hydrochemical regime of the basin, the location in it of the source of the ore matter, the physical properties of rocks along which the metalliferous solutions have been migrating.

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